How to Make a (More) Environmentally Friendly Rocket Fuel

Every NASA launch leaves a huge cloud of exhaust and nasty chemicals in its wake, but NASA has long been trying to do better. Alternative, more environmentally friendly rocket fuels have made a number of advances in recent months. Here are some of the latest options to fuel a cleaner, more efficient rocket launch.

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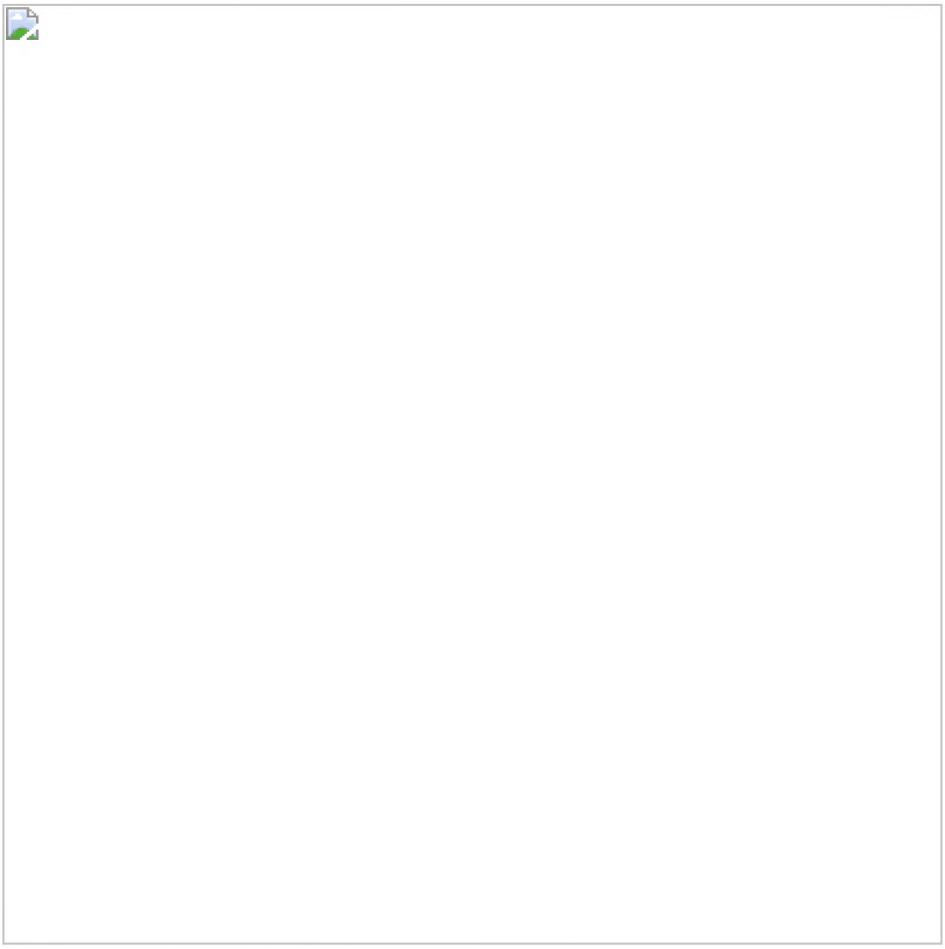

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(Photo by Bruce Weaver/AFP/Getty Images)

Every NASA space shuttle launch leaves a huge cloud of exhaust in its wake, and some nasty chemicals lurk in the exhaust. Solid booster rocket fuel requires perchlorate oxidizers to provide oxygen to react with the propellant, and during a launch those reactions create great quantities of hydrochloric acid—230 tons, to be exact. Hydrochloric acid is corrosive and highly soluble in water, and high concentrations can make waterways too toxic for fish. NASA also found that toxins like hydrochloric acid had reduced the number of plant species in the areas near launch sites. The leftover perchlorates in spent rocket fuel are bad news, too. At higher concentrations they can affect thyroid function in humans, and since 2002 the Environmental Protection Agency has weighed on what are acceptable perchlorate levels for drinking water. In short, blasting rockets into orbit can be an expensive and dirty business. So for years NASA and the Air Force have been seeking new rocket fuels that can not only outperform today's boosters but also release fewer chemicals capable of contaminating the environment and our own bodies.

One of the contenders took to the sky for the first time on August 7. Following two years of research, the team, led by Purdue and Penn State University scientists, launched their test rocket 1300 feet into the Indiana sky using a new propellant mixing aluminum and water ice, called ALICE. If aluminum and water sounds like a simple solution, it is, says Purdue's Steven Son. He says engineers have known for years that the metal reacts exothermically with water, giving off energy. But now aluminum-based material has become practical thanks to the advent of nano-materials. While standard aluminum alloys require a lot of heat to ignite the reaction with water ice—around 2000 degrees C—nano-aluminum has much greater surface area and will begin reacting with water at just more than 700 C, Son says. In fact, you could light nano-aluminum with nothing more high-tech than a cigarette lighter.

Beyond the ease of ignition, the chemical makeup of aluminum–ice fuel means less toxic leftovers. The combustion reaction produces hydrogen gas with a side product of aluminum oxide, which Son says is a drastic improvement over the hydrochloric acid, carbon monoxide and nitrous oxide that solid propellants produce. But ALICE isn't as clean-burning yet as it could be, according to Mitat Birkan of the Air Force Office of Scientific Research, one of the experiment's sponsors along with NASA. The aluminum oxide byproduct of ALICE is not as harmful as the hydrochloric acid produced by a space shuttle launch or the perchlorates in spent fuel, but it's still "dead

weight," Son tells PM. The team plans to tinker with the chemistry and try to optimize the reaction before more test flights, Birkan says; new additives like hydrogen peroxide could help the reaction leave behind fewer wasteful remnants.

Cleaner Rocket Fuel Photo Gallery

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ALICE isn't the only contender for a cleaner-burning rocket fuel. In the 2000s, NASA and the Air Force have been tinkering with a hybrid fuel based on paraffin wax, which humans have been burning in candles for millennia. Stanford University researchers began working with paraffin as a propellant in 2001, excited by the fact that the reactions produce only water vapor and carbon dioxide, and the CO_2 is minimal compared to that produced by cars and trucks because rocket launches are rarer occasions. Several agencies, including the European Space Agency, have experimented with plasma thrusters to use once a craft reaches space. These models use the sun's energy to ionize the gas inside, then emit a beam of plasma to provide propulsion.

Private space flight companies are trying to create less waste as well. Xcor Aerospace has experimented with both methane and kerosene–liquid oxygen engines for taking tourists to the brink of outer space. This May, Virgin Galactic tested a peculiar propulsion system that uses a form of rubber and liquified nitrous oxide. While Virgin's system creates byproducts like carbon monoxide, the company claims the fuel is relatively clean-burning because the rocket launches from the air and burns for a shorter duration than if it were ground-launched.

Still, while NASA, the Air Force and aerospace organizations across the world continue to seek out "greener" and cheaper rocket fuels, these alternatives won't get off the ground if they can't match the capabilities of our current rocket fuels. For the ALICE test flight, "our overall performance is a little less than standard rocket fuel," Son says. However, he believes changing the chemistry before future tests will make ALICE more efficient than the fuels we have now by as much as 25 percent. And while nanoscale aluminum powder is expensive, Son says ALICE carries one advantage over current booster rockets: its simplicity. We know Mars boasts water ice and the moon is packed with aluminum. In a grand vision of space travel, Son says, if travelers could make a propellant like ALICE with ingredients present on other worlds, those worlds could one day become interplanetary refueling stations